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Is Taxing Waste a Waste of Time?

Evidence From a Supreme Court Decision

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February 17, 2016

Abstract

Many people are against a garbage tax even though it often works. We study how a Supreme Court decision, mandating Vaud, a region of Switzerland, to implement a tax on garbage, affects garbage production and beliefs about the tax. Our empirical approach exploits that parts of Vaud already implemented a garbage tax before the mandate, allowing us to adopt a difference-in-differences approach. Pricing garbage by the bag (PGB) is highly effective, reducing unsorted garbage by 40% (arc-elasticity of -0.3), increasing recycling of aluminum and organic waste, without negative spill-overs on adjacent regions. We also find that people are very concerned with PGB *ex ante*, but implementing PGB reduces concerns with effectiveness and fairness substantially. After implementing PGB, people intend to vote for an up to 70% higher garbage tax compared to before PGB. Taxing garbage generates benefits worth 36 % of garbage management costs.

Keywords: Unit pricing; Recycling; Effectiveness; Difference-in-differences; Acceptability; Social perceptions

JEL Codes: D62; D78; H23; Q53

1 Introduction

In 1920, the British economist Arthur C. Pigou proposed a solution to a central problem with markets. If my actions have negative consequences on other people, but I do not pay for them, I will undertake them more often than I should. In a market, the price for my action will be too low, not reflecting all

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the costs of my action on other people. Pigou (1920) proposed to remedy the problem by raising the price of my action so as to internalize the social cost of my actions. Markets work once governments use subsidies or taxes to set the right price.

Pigou's insight is the foundation of environmental economics, waste management included. My waste pollutes the air other people breathe and possibly the water other people drink; it also contains many valuable raw materials, such as glass or aluminum. Without intervention, I will produce more waste than is desirable for society. Pigou's is to set a price the waste I produce, a garbage tax.

The logic of Pigou's proposal is compelling. But the real world seems either not to understand it or not to accept it. Pay-per-bag fees and other measures of waste taxation are not often used in developed countries (see Halvorsen 2012). Why is this so? First, Pigou taxation may not be very effective for household waste. Consumers can find other ways to dispose of their bags, leaking them to areas that do not have pay-per-bag policies, or consumers may not want to reduce waste production. Second, unit-pricing schemes may not be popular, an obstacle environmental taxes often face. Consumption taxes are regressive (Fullerton and Kinnaman 1996, Husaini et al. 2007). Voters may be opposed to pay-per-bag schemes because they do not trust the instrument's effectiveness, or its fairness.

We study both effectiveness and acceptance of a pay-per-bag tax. On July 4, 2011, the Supreme Court of Switzerland mandated all municipalities in the Canton of Vaud, in Western Switzerland, to implement Pigou's polluter pays principle to household waste by January 1, 2013. This ruling created a quasi-experimental situation. Some municipalities had, already before the mandate, implemented pay-per-bag fees and were unaffected; these are the control municipalities. Other municipalities were forced to adopt pricing garbage by the bag (PGB) fees to comply with the mandate; these are the treated municipalities. We compare the evolution of outcomes in treated municipalities to control municipalities, before and after 2013, to learn about the effects of PGB.

Our analysis uses three sources of information. First, we conducted short telephone interviews with people living in treated and control municipalities, in fall 2012 and in spring 2013. We asked questions related to the policy's effectiveness: waste production and recycling behavior. We also integrated a module designed to assess people's attitudes and beliefs about the policy. We were interested in perceptions concerning the effectiveness of the tax and its fairness. Second, we collected administrative data on incinerated garbage, at the municipality level, from 2008 to 2013, to assess whether

the evolution of incinerated garbage is comparable across treated and control communities, the key requirement for a difference-in-differences analysis. We also compare our survey-based estimates of the effects of PGB to administrative estimates. Third, municipalities adopting PGB often facilitated waste disposal to their citizens. We conducted a telephone survey with municipalities and collected data on additional measures undertaken by municipalities to assess to what extent PGB is a pure price effect as opposed to e.g. ease of access to waste management facilities.

Our results indicate that PGB strongly reduces the volume of incinerated waste. Both survey data and administrative data indicate that the tax reduces the quantity of incinerated garbage by about 40%, which translates into an arc elasticity of -0.3. PGB increases recycling of aluminum and organic waste. Glass, paper, and carton recycling increases, but estimates are not significant with control variables. A key concern with PGB is leakage, people leaving their waste elsewhere to save on the garbage tax. We study leakage by comparing Vaud municipalities, with PGB, to their neighbors in Geneva, without PGB. We find no evidence of leakage.

Our findings suggest that PGB is highly effective in reducing incinerated waste. What do inhabitants of the affected communities believe regarding the PGB's effectiveness, fairness, and political acceptability? Before PGB implementation, inhabitants of treated municipalities are concerned that PGB will not work, and believe the tax is unfair. Implementing PGB reverses the situation: inhabitants in treated villages believe PGB is more effective and fairer, eventually converging to the beliefs in non-treated municipalities, who had PGB throughout. Does better perception of the garbage tax matter for policy? We asked people about the maximum price of one garbage bag they would vote for. This maximum price that is, on average, 70% higher after implementing PGB, suggesting that PGB would be better accepted in a poll after its introduction than before.

Our study is related to the literature assessing the effectiveness of garbage taxes. Kinnaman (2006) and Yang and Innes (2007) survey this literature, highlighting that not only solid waste but also that the frequency of sorting should be considered. Jenkins et al. (2003) emphasize that the frequency of recycling should be assessed. Several different types of garbage taxation exist, such as pricing garbage by the bag (or by tags, stickers), weight pricing and subscription programs. Subscription programs tend to under-perform the other two schemes, as the marginal cost of additional garbage may be zero if households remain stuck with a given number of containers for which they subscribed (Kinnaman and Fullerton 2000; Kinnaman 2006). According to the review of Kinnaman (2006),

pay-per-bag fees and weight programs perform in a very similar way (in common units, i.e. kilos of garbage reduction per dollar of user fee), but operating weight programs is generally much more costly. Compressing waste to reduce volume under pay-per-bag fees (the so-called Seattle Stomp) does not represent in most cases a real issue for volume pricing. One would expect volume pricing to also incite consumers to look for less voluminous wrapping while shopping (Jenkins et al. 2003). The estimates for pricing garbage by the bag reviewed in Kinnaman (2006) range from about 1 to 10 kg of avoided incinerated waste per households per week per 1$ fee. Reported price elasticities of demand range approximately from -0.08 to -0.39 (Kinnaman 2006), pointing to incinerated garbage as a relatively, but not completely inelastic good and thus potentially supporting the fee's effectiveness. This reconciles unit-pricing schemes with other types of environmental taxes. To date, a limited number of studies deal with endogeneity in garbage taxation, modeling the policy decision in a first stage (Kinnaman and Fullerton 2000) or using information on the adoption of unit pricing as a proxy for 'environmental activism' in a pooled model (Dijkgraaf and Gradus 2004, see also Dijkgraaf and Gradus 2009).

On the question of public acceptability, the literature is much less developed. Distributional issues are evaluated by Kinnaman and Fullerton (2000), which estimate the income elasticity of incinerated garbage between 0.05 and 0.57 (thus making unit pricing regressive). Environmental taxes may be in general perceived as a constraining instrument, for instance as opposed to subsidies (Steg et al. 2006). A recent strand of literature on the acceptability of carbon taxes emphasizes how the incentive effect of environmental taxes may be misunderstood by the public and this may make "Pigouvian" taxes be felt as Ramsey taxes unless revenues are earmarked (see e.g. Thalmann 2004; Dresner et al. 2006; Kallbekken and Sælen 2011; Kallbekken et al. 2011 and Baranzini and Carattini 2016). Yet, the cross-country comparison of Husaini et al. (2007) suggests that, where implemented, unit pricing enjoys a relative popularity among the general public. This may be a signal that acceptability *ex ante* and *ex post* differ.

Our study complements the existing literature in at least three ways. First, we study effectiveness and beliefs in a setting that forces an entire jurisdiction to adopt a change. This is a unique setting, allowing us to document both what PGB does, and how it affects people's perceptions. Earlier research is largely based on jurisdictions that voluntarily adopt PGB. Effects on voluntary adopters may differ from effects on municipalities forced to adopt, so the effects we can document in our

setting fill an important gap in the literature. Second, our assessment is based on a transparent and plausible empirical design. We follow the same set of municipalities both before and after adoption of PGB, allowing us to document our findings in a difference-in-differences setting. Third, we have collected an extensive set of data on municipalities and individuals containing information on waste, perceptions, and beliefs. While the data on waste production are fairly standard, we are not aware of other studies that have tracked perceptions and beliefs in similar detail.

The next section provides information on waste collection in Switzerland and a literature review. Section 3 provides background on the data sources, and a first descriptive overview. Section 4 presents our empirical strategy, difference-in-differences, and discusses the identifying assumptions. Section 5 provides our evaluation of the effectiveness of pay-per-bag fees. Section 6 shows how introducing a pay-per-bag fee changes people's perceptions. Section 7 concludes.

2 Waste Management in Switzerland and the Canton of Vaud

In Switzerland, municipalities manage the waste disposal, either directly or joining forces in regional companies that take care of the full process for several shareholder municipalities. Regional companies collect and weigh garbage, which is then incinerated in local plants, also funded by public capital from municipalities or the Canton. Regional companies re-inject recycled materials in the production cycle.

Households are charged for this service by the municipality in which they reside. Absent any Pigouvian policy, all waste management costs are raised independently of the quantity of garbage that the household produces. Most commonly, waste management costs were covered by lump-sum taxes calculated based on the number of household members in adult age. Municipalities (as well as Cantons and the Federal Government) can raise income taxes, but these are generally not used to pay for waste management.

Households are free to recycle or not, based on the incentives that they face. Drop-off centers are available in all densely populated areas as well as in rural municipalities. Most of them allow the disposal of the following materials: PET, carton, paper, clothes, glass, cans, organic waste, batteries, and aluminum. In many apartment buildings, paper and carton are collected within the building's premises.

Unit pricing has existed for about two decades in Switzerland, but in a very heterogeneous fashion.

Unit pricing is frequent in the Swiss-German, Eastern, parts of Switzerland. In the Western parts of the country it is limited to the Cantons of Fribourg and Neuchâtel (unit pricing introduced in 2012) and to some municipalities of the Cantons of Jura, Vaud and Valais. The cantons Jura and Geneva, are known to have been historically averse to such policy.

Heterogeneity is the result of the principle of subsidiarity, according to which municipalities have the right to decide their own way to deal with waste management unless cantonal or federal laws prescribe otherwise. A limit to the principle of subsidiarity comes however from the 1997's federal environmental protection legislation imposing the principle of causality in waste collection management, thus forcing the implementation of unit pricing at the municipal level.

In the Canton of Vaud this legislation was nevertheless not enforced until a 2011 lawsuit led to a Federal Supreme Court's ruling. The Federal Supreme Court mandated all municipalities in the Canton of Vaud to implement unit-pricing schemes financing most of waste collection. Lump-sum taxes are only allowed as a complementary source of revenue. This decision started a legislative process at the municipal level that generated a large wave of unit pricing implementations in the Canton.

Our analysis focuses on municipalities that switched to a system of pricing by the bag. Pricing for garbage is identical all across the canton, e.g. the price for 17 liter bag is 1 CHF or about 1 USD, for a 35 liter bag it is 2 CHF, etc. When switching to PGB, municipalities decreased the lump-sum taxes used to fund waste management costs, as prescribed by the federal institutions overseeing regulated prices in the country.

3 Data

In this Section, we first discuss how we defined treated and control municipalities, how we collected the household survey data, and provide a first descriptive overview of the main variables.

Treatment and control municipalities Before 2013, 86 municipalities had already introduced some form of unit pricing, 58 municipalities using PGB. By November 2013, 162 municipalities had modified their laws in order to introduce unit pricing by January 2013, 158 introducing PGB. A total of 121 municipalities had not reached a decision on introducing PGB by January 2013.[1]

[1] Among them, a few municipalities introduce PGB later during 2013, and are excluded from the econometric analysis. Note that due to ongoing merging processes, the number of municipalities slightly differs between 2012 and 2013.

Our analysis focuses on municipalities that introduced PGB by January 1, 2013. We separate these municipalities in two groups. The 58 municipalities that introduced PGB before January 1, 2013, are 'control' municipalities, as they did not change PGB status. The 158 municipalities that introduced PGB on January 1, 2013, are 'treated' municipalities.

We collected data on control and treated municipalities from three sources: a household survey, municipality level data on waste, municipality survey on waste management policies, introduced along with PGB.

We designed the household survey study as follows. We randomly selected 48 municipalities from the set of control municipalities, and 22 municipalities from the treated municipalities. We then contacted a professional survey company which provided us with a random sample of at most 30 addresses of people within each municipality in our sample. Overall we had 1380 addresses for the control group, and 599 for the treatment group.[2]

A team of four of our students administered two rounds of telephone interviews to households in our sample. The first round of interviews took place between November and December 2012. Because of the time constraint, we did not manage to contact all households we sampled initially, but made calls to 70% of the households before January 1, 2013, the date of the policy change. We collected data from 228 households in the control group, and for 124 households in the treatment group. The response rate in this first round of interviews is 25% for both groups.

The second round of interviews took place between April and June 2013. Out of the 352 households that participated in the first round, 193 households participated also to the second round, 107 households in the treatment group, and 86 households in the control group. We will use data on the 193 households participating in both interview rounds in our difference-in-differences analyses. The ratio of households responding to the second round of interviews to the total initially contacted households, the total response rate, is 15%.

Interview data provides rich information on individuals, but is certainly not representative of all individuals living in treated and control municipalities. To address this, we also collected administrative data on incinerated waste, available for all municipalities. This data provides information on the quantity of solid waste produced per household in a municipality. It is available from 2008 to 2013. The data covers the entire canton of Vaud, allowing is to assess to what extent selection of

[2]The sampling rates are not the same across treated and control municipalities as control municipalities were smaller than treated municipalities.

households and municipalities matters for our estimates.

Many municipalities introduced measures that made it easier for their citizens to dispose of their waste when they shifted to pricing garbage by the bag. These measures constitute a possible confound. We deal with this confound by collecting detailed information on these measures as follows. We contacted the member of the municipality councils in charge of waste management for all municipalities covered by the survey panel data. We administered a supplementary questionnaire capturing the variation in the number of curbside programs, of collection centers, of skips, in the opening hours of existing collection centers and in the frequency of raising-awareness initiatives taking place between the two periods. Of the 82 municipalities for which we observe at least one household, we obtained answers for 44 municipalities. We will pay attention to possible selectivity of this sub-sample of 44 municipalities in our estimates below.

Main Variables This paragraph presents the main variables from the household survey that we use in our main analysis. The survey is structured in three parts. In the first part, we ask households about their behavior regarding solid waste and recycling of the following 9 materials: PET, carton, paper, textiles, glass, cans, organic waste, batteries, and aluminum. The second part of the questionnaire concerns unit pricing's perception and acceptability. The final questions provide us with the standard socioeconomic variables (cf. Table A.1).

Table 1 presents the descriptive statistics for the outcome variables concerning unit pricing's effectiveness: solid garbage per household and per capita, recycling of the 9 materials and attention to voluminous wrapping. Descriptive statistics are given for the treatment and control groups for 2012 and 2013. Solid waste is measured in liters per week. This value is obtained by multiplying the number of bags used per week with their volume (17 and 35 liters are the most common sizes). 15 households do not report their solid waste production in either 2012 or 2013 (or both). Taking into account these missing values, total observations for solid waste are 371. Recycling variables take value 1 if the household sort a given material and 0 otherwise.[3]

[3]We do not measure the intensity of recycling but rather the probability of doing it. Arguably we can assume that households stating that they recycle a given material do it in most cases, even though probably not in all. Viscusi et al. (2011) describe recycling as a dichotomous choice with corner solutions, i.e. people recycle or do not recycle at all. This is the result of the following proposition: if for a given household it is desirable to recycle n units of material, then it is likely to be desirable to recycle $n+1$ units. The choice of frequency over intensity of recycling clearly simplifies the task to interviewees, which are not asked to estimate the share of a given material that is recycled. This estimation may indeed be cognitively demanding and possibly lead to a substantial difference between stated and reported behavior (Sterner and Bartelings 1999). We apply a binary simplification also to voluminous wrapping: we ask to households whether they pay attention to wrapping or not.

4 Empirical Strategy

In this Section, we explain the empirical strategy and discuss the external validity of the household survey data.

Empirical framework In this Section we introduce the role of policy endogeneity and the possibility for confounders to bias the estimations of pricing garbage by the bag's effectiveness (cf. Besley and Case 2000). We collect data for households both in a treatment and a control group before (in 2012) and after the treatment (in 2013) and apply a difference-in-differences approach. Household i's garbage production in municipality c at time t is given by Y_{1ict} in presence of PGB and Y_{0ict} otherwise. We assume the level of garbage production absent any treatment to be dependent on time (λ_t) and municipality characteristics (γ_c the municipality-specific fixed effect) such that

$$E(Y_{0ict}|c,t) = \gamma_c + \lambda_t \tag{1}$$

gives the counterfactual. Let $D_{ct} = 1$ if municipality c has PGB at time t. Our empirical model is:

$$Y_{ict} = \gamma_c + \lambda_t + \beta D_{ct} + \epsilon_{ict} \tag{2}$$

where the error term ϵ is such that $\mathrm{E}(\epsilon_{ict}|c,t) = 0$. The parameter $\beta = E(Y_{1ict} - Y_{0ict}|D_{ct} = 1)$ captures the average effect of introducing PGB in municipalities that adopted PGB in compliance to the Supreme Court mandate. The average effect might vary across municipalities for socio-economic reasons, but not because of differences in the garbage tax, as the tax is linear and set at the cantonal level.

The key identifying assumption requires that the trend in the treated outcome, Y_{1ict}, in municipalities that had PGB before the mandate, or control municipalities, is the same as the trend in the non-treated outcome, Y_{0ict}, in municipalities that adopted PGB in compliance with the mandate, or treated municipalities.[4] We assess this identifying assumption below using several years of data before the policy change. If the underlying assumptions are verified, an OLS estimate of our key

[4] Our assumption is somewhat different from the standard identifying assumption in difference-in-differences contexts, asking for parallel trends in the outcome without treatment in treated and control municipalities. The control group in our setting is always treated whereas the control group is never treated in the standard setting.

empirical specification (2) provides unbiased estimates of the average causal effect of our treatment. In all estimates, we allow for clustering of the errors at the municipality level.

Household characteristics may vary between municipalities and groups, so we will assess sensitivity of our results to control variables X'_{ict} for household i in municipality c at time t to test the robustness of (2):

$$Y_{ict} = \gamma Be_c + \lambda d_t + \beta D_{ct} + X'_{ict}\delta + \epsilon_{ict} \tag{3}$$

Some of the outcomes that we observe are binary. For instance, a variable capturing whether a household i in municipality c sorts at time t a given material takes either value 1 if the household does or value 0 if it does not. We may thus want to rewrite equation (2) as a probability model. The fixed-effect panel data model now writes as:

$$Pr(Y_{ict} = 1) = Pr(Y^*_{ict} > 0) = Pr(\epsilon_{ict} > -\gamma_c - \lambda_t - \beta D_{ct}) = F(\gamma_c + \lambda_t + \beta D_{ct}) \tag{4}$$

where F follows a normal distribution. Since the number of unknown parameters γ_c increases with N for a fixed T, such specification would face the incidental parameters problem, which implies that the coefficients for the municipality-specific fixed effect are inconsistent. Applying a random-effect model allowing for a Chamberlain/Mundlak correction introducing the mean of time-varying variables in the main specification would help, but this would not be possible absent time-varying independent variables. We hence estimate (4) by "brute force" (cf. Greene 2011), knowing that this technique introduces an upward bias of 100% when T=2 as in this context, and compare it to linear regression.

Our approach deals with bias in cross-sectional studies (Kinnaman and Fullerton, 2000). On the one hand, environmental-friendly communities may be relatively more likely than others to introduce unit-pricing systems. Cross-sectional comparisons may thus overestimate the policy's effectiveness, since these communities may generate lower amounts of garbage anyway, i.e. regardless of the policy. On the other hand, communities with very high levels of garbage per capita may consider to implement such policy to converge towards a "standard" level of garbage production. Efficiency reasons may also support this second source of endogeneity (Dijkgraaf and Gradus 2009). Cross-sectional comparisons may thus underestimate the policy's effectiveness.[5]

[5]Kinnaman and Fullerton (2000) attempt to identify the direction of (and correct for) this self-selection bias by estimating in a first stage the endogenous likelihood of implementing a unit-pricing system. Their finding suggests that the second source

Time-series analyses for the same community, as in Fullerton and Kinnaman (1996), do not face this issue, but, absent any control group acting as counterfactual, estimates may be biased by trends (i.e. simultaneity). This bias may be very large if garbage is measured at different moments of the year, as seasonal variation may be considerable (cf. Sterner and Bartelings 1999; Yang and Innes 2007). Other elements, such as citizen's environmental friendliness, may also change over time. Non-tax policies (e.g. awareness-raising campaigns) may also affect the amount of solid garbage produced by households. In Fullerton and Kinnaman (1996) the authors collect data for other communities, regarded as similar, in an attempt to correct their estimates.

External validity About 15 % of the households we contacted initially participated in the survey. Moreover, since we select a series of municipalities in both groups and the number of addresses received is bounded regardless of the municipality's size, our sample is not representative of the cantonal population. [6] This means that using survey data may not provide a representative picture of the municipalities, limiting external validity. The question of external validity is particularly important when assessing pricing garbage by the bag's effectiveness.

We tackle this issue as follows. First, we compare for each group the characteristics of the households participating only to the first round of interviews with the sample interviewed twice, i.e. our panel. Table A.1 provides mean comparison of all variables. We highlight all variables for which the statistical test suggests that the averages are different between the samples. A few variables are statistically different, e.g. education, income, distance from collection centers. Data in Table A.1 allows also to compare the characteristics of the treatment and control groups. Treatment and the control groups suggest that the two groups are fairly homogeneous. However, given also the risk of sample selection, we present both models without and with covariates.

Second, we compare estimates from survey data with official data measured by municipalities. We compare the evolution of solid garbage per capita and assess whether treatment and control groups follow parallel trends from 2008 to 2012. Second, we can run estimations of model (2) with the

of bias may dominate, i.e. simple cross-sectional analysis would underestimate the policy's effectiveness. Dijkgraaf and Gradus (2004) use the decision to adopt unit pricing as signal of 'environmental activism'. Controlling for 'environmental activism', the authors find with panel data a lower estimate for unit pricing. They hence argue that this variable helps correcting for the policy endogeneity. Based on their finding they suggest that the first source seems to dominate, i.e. simple cross-sectional analysis would overestimate the policy's effectiveness. Allers and Hoeben (2010) use the tax rate of unit pricing in neighboring municipalities as instrument for the likelihood of implementing unit pricing. This approach does not improve the estimates for unsorted waste, but it does for organic waste.

[6] For illustrative purposes, comparison of the sample with the cantonal population can be done on the basis of Tables A.1 and A.2, which show for a series of socioeconomic variables the average values for our sample and for the cantonal population.

administrative data for the subset of municipalities composing the survey sample and compare with the survey estimates. Third, we exploit the full scope of the administrative data and run estimations of model (2) with all municipalities already pricing garbage by the bag by the end of 2012 as (extended) control group and all those starting to price garbage by the bag on January 1, 2013, as (extended) treatment group. This procedure is important to determine whether our selection of municipalities has any influence on the outcomes studied here. Fourth, comparison with other types of policy, such as based on weight, is also undertaken.

5 Is PGB a Waste of Time?

In this section, we present the main results on the policy effectiveness. We start by studying the evolution of waste over time in treated and control municipalities. We then show effects on waste, and recycling based on survey data. We then present evidence based on administrative data, discussing issues with external validity and representativity in our survey sample. We discuss how to test for leakage, waste wandering into adjacent municipalities that have no pay-per-bag fees.

Parallel trends We look at the parallel trends by comparing the average weight of incinerated waste, official data, produced by municipalities in the treatment and in the control group. Yearly data are available since 2008, normalized by the number of inhabitants (i.e. kilos per capita). Figure 1 shows average garbage in treated municipalities and control municipalities who never changed their PGB status between 2008 and 2012. Both groups follow a horizontal path with only a limited amount of variation around the steady line given by their level of incinerated waste in 2008. This variation is marginal compared with the large difference in solid waste production between the two groups, which is narrowed only in 2013 when the treatment group is subject to treatment.[7]

Results for Garbage We start by assessing the treatment effect on the amount of solid waste produced by households in the survey. Provided that there is an effect on solid waste, we then need to verify that this is accompanied by an increase in recycling and in the concern for wrapping materials, to ensure that households respond to the fee in a desirable way. The top panel of Figure 2 shows the variation over time in the volume of solid waste per capita per week in the treatment and control

[7]We have tested parallel trends by implementing a placebo introduction of PGB for treated municipalities in 2009, 2010, 2011, and 2012. The placebo effects are all not statistically significant, and smaller than 10 percent of the treatment effect, in absolute value.

groups. The bottom panel zooms on the difference and provides a first approximation of the difference in differences, which is of about -10 liters and statistically significant, as indicated by the confidence intervals.

Column (1) in Table 2 translates this effect into numbers, by estimating model (2) with ordinary least squares (OLS).[8] We introduce control variables in column (2) and thus estimate model (3). Since some missing values affect control variables, in column (2) the number of observations is slightly reduced, from 371 to 359. In both columns the dummy associated with the year 2013 is statistically significant. This confirms the need for a counterfactual. In this specific case, the counterfactual implies a decline of about 3 liters per capita per week, regardless of unit pricing. The treatment effect amounts to about -10.5 liters per capita per week. By introducing control variables in column (2), we test whether this effect is robust to possible differences in the groups' socioeconomic composition. Column (2) shows that it is. The coefficient for the treatment is indeed statistically unchanged. However, several control variables are statistically significant and the goodness-of-fit as measured by the within-R^2 also substantially improves. We thus point to model (3) as the appropriate specification and discuss the estimates accordingly.

In 2012, the average solid waste volume per capita per week in the treatment group was slightly above 27 liters. This implies that the treatment generates a decline in solid waste of about 40%. The effect of Table 2 is in the range of what found by e.g. Fullerton and Kinnaman (1996), a decrease in volume of about 37%, and Yang and Innes (2007), a decrease in volume of about 27%. In computing the price elasticity of demand we follow the strategy outlined by Kinnaman and Fullerton (2000) and find an arc-elasticity of about -0.3.[9]

Results on the control variables indicate that EU nationals tend to produce per week about 4 liters more of solid waste than their Swiss homologues (the reference case), whereas no effect is found for citizens of countries other than the EU and Switzerland. This effect may be due to cultural differences or different levels of experience with recycling.

A high level of education as measured by possessing an university degree is related to less solid waste per week per capita (about 8 liters) compared to having completed only the compulsory edu-

[8] OLS is used in all specifications unless otherwise specified. Fixed effects are justified by a $\chi^2(2)$ of 32.08 ($p > \chi^2(2) = 0.0000$) in the Hausman test for model (2) and a $\chi^2(25)$ of 62.53 ($p > \chi^2(25) = 0.0000$) for model (3). We use clustered standard errors (clusters per municipality) in all specifications where it is justified by the standard heteroscedasticity tests such as modified Wald and Breusch-Pagan/Cook-Weisberg tests.

[9] On average bags are priced at 1.5 francs. Absent any tax, the retailer price of a bag was slightly above 0, around 0.17. The arc-elasticity resulting from an increase in price from 0.17 to 1.5 is the same as the point-elasticity at a price of 0.665. We hence get -9.67·0.665/((27.4+10.5)/2)=-0.34.

cation (the reference case). It is indeed common in the literature to have pro-environmental behavior positively associated with education (cf. e.g. Jenkins et al. 2003 for the case of garbage).We control for income using the six categories of the questionnaire and thus mirroring the classification in the official statistics. The sixth and highest category is the dummy of reference. To deal with the many missing values, we include another dummy variable taking value 1 if income is not reported. The coefficient for this variable is negative and statistically significant as are those for other low-income categories (income 1 and 3), suggesting some self-selection related with lower incomes. The negative effect for low-income households is in line with the economic prediction, since high-income households have larger levels of consumption and higher opportunity costs of recycling. Gender, age and green membership have no significant effect on the amount of solid waste produced by the household.[10]

We find a negative effect for the number of adults in the household. The literature points to economies of scale (cf. e.g. Sterner and Bartelings 1999; Halvorsen 2008, 2012) and especially to a better allocation of recycling tasks within large households, taking into account the differences in opportunity costs. Unfortunately we cannot control for the living area, which could also be contributing to this effect (cf. Sterner and Bartelings 1999). We know however whether the household owns or rents its housing (cf. also Halvorsen 2012; Abbott et al. 2013), and in the Swiss context ownership is usually associated to single houses rather than apartments. Table 2 shows that the coefficient for renting (with respect to owning) is not statistically significant.

The statistically significant coefficient for distance from a collecting center shows the importance of installing collection centers close to the final users reducing the households' cost of recycling. We relate this finding to the vast literature on the effectiveness of drop-off centers and curbside recycling programs (cf. e.g. Jenkins et al. 2003; Kinnaman 2006; Halvorsen 2008; Hage et al. 2009).

Effects on Recycling How did pricing garbage by the bag affect recycling? Table 3 reproduces the same approach of Table 2 for all recycling materials plus wrapping and thus provides evidence on the treatment's recycling-side, based on survey data. Since dependent variables measure a discrete change, we also run a Logit model, as detailed with respect to equation (3). Estimates from Logit are reported in the bottom panel. Since estimates from Logit are very similar to those obtained with OLS, taking into account the brute-force bias (cf. Greene 2011), and given the lost observations

[10]We note the following qualification: socioeconomic variables are given for the household's representative answering the questionnaire, whereas waste management is rather a household decision.

when success or failure are perfectly predicted, we comment the empirical results based on estimates from OLS. Logit models do not substantially improve the estimations controlling for socioeconomic variables, either.[11]

In the top panel we apply model (2) to the frequency of recycling. The year dummy is never significant, which introduces a difference compared to Table 2. Treatment effects have the expected sign and are the largest in the case of aluminum and organic waste. The estimate for aluminum suggests that pricing garbage by the bag leads almost a quarter of the sample to start sorting this material. It does not surprise that these two materials enjoy the larger increase in the frequency of recycling. Organic waste is mainly associated with bad smell and other practical issues, whereas aluminum often comes in tiny quantities which, taken alone, may not induce people to start sorting without monetary incentives.[12]

In the following panel we introduce controls as in model (3). Again, the use of control variables implies a slight reduction in the sample size, e.g. from 386 to 368 for recycling materials. Only the treatment effects for aluminum and organic waste are robust to the inclusion of control variables. That is, the most conservative estimates from columns (1) and (6) confirm that there is an increase in the frequency of recycling of organic waste (of about 14%) and of aluminum (of about 20%). These effects are not only statistically significant, but also considerably large from an economic perspective. Regarding batteries, carton, glass and paper the coefficients remain positive, but are no longer large enough to reach significance.

Statistically significant control variables include (depending on the specification, full details reported in Table A.3): age, EU and rest-of-the-world citizenship, distance and a few income categories (mainly low-income). We discuss the possible rationales for some of these effects. Age is positively associated with the frequency of organic waste, paper and PET recycling. Age itself may determine the likelihood of sorting these materials (cf. e.g. Jenkins et al. 2003; Hage et al. 2009), but it is also common that elderly enjoy large apartments whose rents are not adjusted to the current market prices. Again, we do not control for the size of living area. Cultural differences linked with the nationality seem supportive of the evidence provided in Table 2, with Swiss nationals being probably

[11] All additional estimations are available by the authors upon request. The statistical significance of the treatment effect on recycling, if any, is robust to the use of false discovery rate q-values for multiple regressions (Anderson 2008).

[12] Conversations with local practitioners indicate that the increase in the number of households involved in sorting organic waste is associated with a decrease in the quality of the latter, with a higher presence of "foreign bodies". It is however suggested that this practices are related with a lack of experience rather than an attempt to cheat. A telling example is the use of non-organic bags for organic waste. There is also little evidence of diffused illegal practices (see Fullerton and Kinnaman 1995) in the context under observation, which reconciles with the Swedish context of Sterner and Bartelings (1999).

better trained to recycling (cf. Halvorsen 2012 for cross-country comparisons of recycling habits). The number of children in the household seems to increase the frequency of recycling of PET, perhaps because children are made particularly aware of it at school. When significant, the effect of income is in most cases as expected: low-income households have a lower opportunity cost and are thus supposed to be more inclined to sort waste.

Finally, the effect of distance from the collection center is negative and statistically significant for all materials except for aluminum and batteries, which may be less difficult to transport than other materials. From Table A.3 we can infer that a decrease in distance of about 10 minutes would lead to an increase in the frequency of recycling of paper of about 6%.

Testing for confounders Many municipalities facilitated recycling at the time of introducing PGB. Neglecting these policies, we would tend to overstate the effectiveness of unit pricing. We now consider the role of this confound using data from the survey to the municipalities. These data measure whether a municipality increased opening hours, launched a raising-awareness initiative, etc. or not.[13] Table 4 gives descriptive statistics for the variables considered in this analysis for both the control and the treatment groups. We observe in Table 4 that non-tax measures increase in both the treatment group and the control group, perhaps due to the salience of the Supreme Court mandate in the entire region.

Estimates from the regressions including potential confounders are presented in Table 5, using survey data. Non-tax variables are not available for the whole sample. Column (1) estimates again the treatment effect as in the respective column of Table 2, but for the subset of households living in municipalities for which we possess data on non-tax measures of waste management. The treatment effect is statistically unchanged with respect to Table 2. The time dummy is instead now statistically non-significant. Column (2) adds variables that indicate the presence of new measure to facilitate recycling. The coefficient for the treatment effect is somewhat smaller but statistically identical compared to the baseline effect in column (1). This result suggests that the garbage tax, rather than the simultaneous change of recycling programs, induced the sizeable reduction in garbage in municipalities that introduced PGB.[14]

[13] We exclude a few measures that affected only a handful of households, i.e. awareness-raising tools such as street stands and specific online websites.

[14] We have replicated results also with administrative data on incinerated waste (see below). Table A.4 shows results that are virtually identical to those with survey data. We have also explored how non-tax variables affect recycling behavior. Results are not affected. The coefficient for organic waste, for instance, becomes 0.130, statistically undistinguishable from the 0.144 of

Most non-tax variables are statistically insignificant and the goodness-of-fit is only slightly affected. As expected, the coefficient for the number of materials covered by new skips is negative, and statistically significant.[15] The coefficient for the curbside program is also negative, but does not reach significance. We also find positive point estimates for better opening hours, new collection centers (statistically significant) and unaddressed mailshots (very small). We suspect this result is driven by reverse causality.

Administrative Data To estimate the treatment effect, we focus first on the amount of solid waste sent to incineration in 2012 and 2013, from official data, focusing on the subsample of municipalities for which we also have survey data. Estimates are provided in Table A.4. The first column shows that the implementation of pricing garbage by the bag causes a reduction in the amount of per capita solid waste of about 86 kilos per year. An "exogenous" reduction associated with the time dummy is again present, confirming the relevance of the difference-in-differences approach. The goodness-of-fit is much higher than in the survey estimations, probably due to a lower variability in the (average) per capita waste production between municipalities than between households. In percentage, with respect to a previous level without treatment of 244 kilos, we find a reduction of about 35%. Hence, the comparison of estimates from Tables 2 (in liters) and A.4 (in kilos) indicates that the two data provide comparable and very close estimates for the effectiveness of pricing garbage by the bag. As noted by Bel and Gradus (2014), a difference is likely to exist mainly when volume pricing is represented by containers instead of smaller units such as bags (see e.g. Fullerton and Kinnaman, 1996). For instance, no difference between weight and bag pricing is found in the Dutch case of Dijkgraaf and Gradus (2004) and Dijkgraaf and Gradus (2009). As discussed, similar evidence is provided by Kinnaman (2006). This consistency seems also very reassuring in view of the external validity of our survey results. Yet, further tests are provided in what follows.

Dealing with possible confounders, we extend the specification of column (1) to control for other policies that could potentially drive some of the effect for the treatment. We do this in column (3). Since we possess data on non-tax policies only for some of the municipalities concerned by the household survey, we should compare the treatment effect with or without these controls based on the same sample. Hence, column (2) estimates the same specification as in column (1) on the restricted

Table 2 and remains statistically significant.

[15] Note that this variable is counts the number of materials covered by new skips, which allows to avoid including correlated skip dummies for each material.

sample of municipalities whose non-tax policy change is known. Even though the reduction in the observations is non-negligible, the coefficients of interests are statistically unchanged between columns (1) and (2). As expected, introducing non-tax policies in column (3) leads the coefficient for the time dummy to become statistically non-significant. Hence, it seems that with these measures we are able to capture the bulk of factors other than pricing garbage by the bag acting upon the amount of solid waste incinerated. Again, non-tax policies reduce the treatment effect, but not in a statistically significant way. Most non-tax control variables are statistically non-significant and the goodness-of-fit improves only marginally. The coefficients for the number of materials covered by new skips and the better opening hours are negative as the economic intuition would suggest, but do not reach statistical significance. The coefficient for a new collection center is instead statistically significant: controlling among others for the new skips for recycled materials, a new collection center is related to about a dozen additional kilos of yearly solid waste per capita. We recall that an additional collection center does not represent an exogenous treatment.

Official data also allow us to test whether the treatment effect found so far applies only to the subset of municipalities chosen in the survey data or whether these are representative of the Canton as a whole. As a result, we reproduce in Table 6 the same approach of Table A.4 using all municipalities in the Canton. For comparison, column (1) presents the estimate of the same column of Table A.4. The treatment in column (2) is still pricing garbage by the bag whereas in (3) all unit pricing schemes are taken as treatment. We recall that data on non-tax policies are not available for the full set of municipalities and thus not used here. Estimates from Table 6 provide further evidence on the external validity of the previous results. Based on 434 observations, 217 municipalities, the treatment effect is estimated in column (2) at about 80 kilos per capita per year of reduced solid waste. This figure is quantitatively undistinguishable from the previous estimates and imply a reduction in garbage per capita of about 40%. Introducing data also on weight programs does not affect the treatment effect in any statistically perceptible way, cf. column (3). However, since only 4 municipalities opt for a weight-based treatment it is difficult to infer from this outcome that effectiveness does not differ across specific pricing schemes.

A central concern with our analysis is the non-random nature of the adoption of PGB. Perhaps treated municipalities, resisting unit based pricing until forced to do so, do not care about the environment and recycling. This might lead in a very large estimate of the effects of PGB on garbage

production right because of the specific initial conditions. Column (4) of Table 6 interacts the treatment with the percentage of votes cast at the municipal level in favor of green political parties at the national election of 2011. This interaction effect is not statistically significantly different from zero, suggesting that the effects of introducing PGB does not significantly vary with the green vote share. Nonetheless, introducing PGB reduces waste by 109 kg per capita, somewhat stronger than the baseline effect of 80 kg per capita. But note that this main effect refers to municipalities with a zero vote share for green parties. In 2011, the average green vote share in the canton was 15.90%. Hence, the effect of introducing PGB for the entire canton of Vaud, at the average green vote share, is -109.37+0.8556*15.90 = -95.8. This effect is slightly stronger than the effect in column (2), suggesting that, if anything, our difference-in-difference provides an under-estimate of the effects of PGB for the entire region.

Effect on surrounding municipalities We assess whether there is scope for leakage by observing the changes in solid waste per capita across the border between the Canton of Geneva, where solid waste is not priced, and the bordering municipalities of the Canton of Vaud, which implemented unit pricing on January 1, 2013. The policy shock in the Canton of Vaud allows us to exploit a sharp regression discontinuity design, where the threshold between the municipalities in the Canton of Geneva and those in the Canton of Vaud is given by the latitude 46°17N (see Imbens and Lemieux 2008 for a methodological review). We thus use the latitude as forcing variable, around the cut-off °17, and an untreated control group. While from a purely theoretical perspective we could be facing some mobility across the border, it is extremely unlikely that households can be tempted to relocate from one side to the other of the border due to unit pricing. Hence, we assume full compliance. We select the optimal bandwith following Calonico et al. (2014).[16]

Our main focus is on the slope of the regression on both sides of the border. If there is leakage, we would expect the amount of solid waste per capita to increase (decrease) in the Canton of Geneva (Vaud) as we approach the border from South (North). However, this exercise also allows us to compare the previous estimates of pricing garbage of the bag's effectiveness with a new set of estimates obtained with an untreated control group. Figure 4 provides the main graphical results. Following the treatment there is a clear jump in solid waste per capita per year, with a difference of slightly

[16]We implement several bandwith selectors as proposed in the literature and in all cases the choice of the bandwith has no implication for the findings of this Section. Data for Geneva comes from OCSTAT (yearly garbage per capita in kilos).

more than 100 kilos. This result seems to corroborate the effectiveness of pricing garbage by the bag. In terms of slope, there is no clear pattern.

Tables 7 and 8 provide quantitative evidence for the results suggested by Figure 4. The jump is estimated at about 107 kilos per capita per year, slightly above but statistically unchanged with respect to the results in the previous paragraphs. In relative terms, the change is again of about 40%, starting from a level for 2012 of about 273 kilos per capita per year. This figure is clearly consistent with the previous discussion. While graphically there seemed to be some leakage, in statistical terms this evidence is not confirmed (cf. Table 7). As shown by Table 8 with simple linear local regressions, the coefficient measuring the slope of the regression is positive (negative) on the left (right) of the threshold, but in both cases it does not reach statistical significance. Hence, we conclude that there is no evidence in favor of a leakage (see also the Swedish case of Sterner and Bartelings 1999 and the Dutch case of Dijkgraaf and Gradus 2004 for comparable findings).

Cost Benefit Assessment To provide an order of magnitude for the financial implications of our findings, we provide a back-of-the-envelope cost-benefit calculation. The direct benefits of taxing garbage are reduced costs of garbage management. Without pricing garbage by the bag the cost of collecting and incinerating garbage is about 194 CHF per individual per year. We suppose that the 40% reduction in garbage following the implementation of pricing garbage by the bag lowers total cost of waste management by 40% to 116 CHF. Switching from lump-sum taxes funding waste management to Pigouvian taxation allows saving about 78 CHF per individual per year.[17]

A second benefit is associated with externalities. PGB reduces the external costs related with the following pollutants released during the incineration process (from Eshet et al. 2006): PM_{10}, NO_X, SO_2, VOCs, CH_4, CO and CO_2. Most of the external costs are related with local pollutants, mainly PM_{10}, NO_X and SO_2. External costs are estimated on average at about 50 CHF per ton of garbage incinerated (Eshet et al. 2006). Individuals produce 200 kilos of garbage per year, a per capita reduction in incinerated garbage of 80 kilos implies then additional gains from reduced external damages of about 5 CHF per individual. External damages from incineration are much higher than from landfill disposal, as estimated by Kinnaman (2006), mainly due to the high emissions of local

[17]Note that in the short run waste management costs might decrease by less than 40%, as long as some costs are fixed. Municipalities may also take some time to reoptimize their collection process and garbage trucks may still service certain routes as often as they did before.

pollutants (see also Muller et al. 2011).[18]

Running a PGB program is costly and so is raising revenue. Production, administration, and control of the system need to be taken care of. We have no direct figures on these costs but consider 5 CHF a realistic value. Kinnaman (2006) reviews two studies providing figures in the order of 10$ (10 CHF) per household, or about 5 CHF per capita. This is equivalent to the environmental benefits of PGB, which are mainly local and can be appropriated by citizens. Hence, we can assume these two items to even out.[19]

The PGB program looks favorably in a cost-benefit assessment. Total benefits of the program amount to 78 CHF, total costs to 5 CHF, so the net benefit is 73 CHF per individual per year. It is useful to put this net benefit in relation to the total cost of waste management without PGB, which is on the order of 200 CHF, 194 due to waste management, and 10 CHF due to external costs. PGB produces net benefits on the order of 36% of total waste management costs, a sizeable return on implementing PGB.

Why do not all jurisdictions adopt unit based pricing? A possible explanation might be that people do not know about how the tax works, or find it unfair. We analyze statements on effectiveness and fairness in the next section.

6 What do People Think?

In this section, we discuss the effects of PGB on voter perceptions and and voting intentions.

Results on Perceptions We address the questions of policy perceptions by applying the same difference-in-differences approach used with respect to the question of effectiveness.

We start our analysis with questions aiming to see whether respondents understand the tax. The variable *perceived effect on the environment* measure whether respondents consider the PGB "as effective, in the sense that it incites the inhabitants of your municipality to recycle more of their garbage and pay more attention to voluminous wrapping" accepting ansers "Yes", "No", and "I don't

[18] Note that these gains may only materialize in the long-term as waste incineration facilities could need to run at full capacity all the time. Reductions in local waste are often compensated with purchases on the spot market. In the long-run, regions may close a waste incineration facility.

[19] A second cost may occur due to the inefficiency of government. Dahlby (2008) estimates the marginal cost of public funds in Switzerland at around 1 to 1.50 CHF, meaning that every tax franc entails an additional cost of 0 to 50 cents. However, the same applies to revenues generated through lump-sum taxes. Overall, PGB reduces waste management costs and so the need for public revenues and the room for inefficiencies.

know". We study the proportion of people answering "Yes" in columns (1) and (2) of Table 9. Socio-economic controls are included in even columns. Since all variables in this paragraph are binary, we compare again estimates from OLS regressions with a fixed-effect Logit model estimated with Greene's (2011) brute force method (cf. Table A.6). Applying Greene's correction we find that the treatment is associated with at least one household over ten changing its opinion in favor of the fee's effectiveness.

We also analyze a variable that measures whether people support using the PGB revenues in a different realm than waste management. Environmental taxes need to be set so that they internalize external costs, possibly creating a sizeable surplus (or deficits). Remaining revenues should ideally be spent on projects with the highest social return, or refunded to the public lump sum. Voters often ask for earmarked taxes since they do not see how improvements in environmental quality can be obtained otherwise. The variable *use of revenues for other purposes* asks respondents "would you accept a pay-per-bag fee whose revenues would be used to fund some public expenditures other than waste management, such as education, safety?" with two types of "Yes", and two types of "No" allowed (detailed answers in the appendix).

Columns (3) and (4) of Table 9 display a large and clearly significant coefficient for the treatment. Again, no change affects the control group. As a result, we may infer that following the experience of unit pricing, an important proportion of respondents (at least one fourth applying Greene's correction) becomes aware of the incentive effect of environmental taxes. Looking at Table A.5, we observe that the *ex post* mean of this variable in the treatment effect attains the level of the control group. The same applies for perceived effectiveness.

In terms of fairness, we asked "In your opinion, is the pay-per-bag fee unfair because you already pay enough taxes?", an item that captures resentment against introducing a new tax. A second item we study considers responses to the question "In your opinion, does the pay-per-bag fee makes you pay even if you already sort your garbage?". This item measures resentments against paying a tax on the quantity of garbage that can no longer be sorted. In both cases, we allow for "Yes", or "No" answers.

Columns (5) to (8) of Table 9 report the estimates for both unfairness items. Looking at the sign of the coefficients for treatment we observe that experiencing the functioning of unit pricing is related to a lower frequency of answers stating a feeling of unfairness driven by both having to pay

new taxes, and having to pay a price on the residual garbage even after having sorted all materials. Implementing the PGB tax reduces both types of resentment, as people understand the mechanism behind unit pricing better.

We also explore the feeling of inequity, since PGB opposes two different concepts of justice, the polluter pays principle, advocating for higher fiscal revenues from bigger polluters, and a social equity principle, stating that fiscal revenues raised from a given individual should depend at least proportionally on her contributive capacity. Given the regressive nature of PGB, the two concepts may be in open conflict.[20] The first item we study is "In your opinion, a pay-per-bag fee favors high-income households and is thus inequitable", allowing for "Yes" and "No" answers. This variable captures resentments against the regressive nature of the tax. The second variable stated "The pay-per-bag fee could imply a higher expenditure for low-income households". Respondents were given a choice between three answers: (1) "I think this is legitimate", (2) "I think that the fee is legitimate provided that low-income households are compensated", or (3) "This fact does not influence your opinion on the pay-per-bag fee". We analyze the proportion of (2) answers.

Columns (9) and (10) of Table 9 present the estimates for the perception of inequitable treatment, while columns (11) and (12) display the estimates for social justice. Introducing PGB does not affect perception of whether the tax is inequitable or legitimate. The point estimates on the treatment effect are close to zero and not significantly different from zero. But both treatment and control groups consider pricing garbage by the bag less inequitable after January 1, 2013, possibly because this large wave of implementations made individuals much more aware of the regressive impacts that alternative sources of revenues for waste management may have. The debate also highlighted the measures undertaken by municipalities to at least partly offset the possible distributional effects.

Experiencing the treatment seems to positively affect the fee's perception, in particular concerning its effectiveness and the related sentiments of unfairness. Seeing the tax work, in one's own household as well as in one's social environment, may change some erroneous beliefs that it is not effective. The stigma of social injustice associated to unit pricing is smoothed in the whole Canton, according to the evidence in our sample, perhaps because the large media coverage at the local level contributed to make clear that policy-induced distributional effects are not an inevitable condition of unit pricing.

[20]The income elasticity of garbage is 0.4 in our sample, so pricing garbage by the bag has indeed a regressive effect.

Voting intentions Individuals become less averse to pricing garbage by the bag once they are forced to live with it. But do people become more willing to implement the Pigou tax on the political arena? We discuss this using data on voting intentions on the bag's maximum price.

In our survey, we asked respondents about the maximum bag's price they would vote for in a ballot, if asked to define the tax rate for pricing garbage by the bag. Specifically, respondents were asked "if you were asked to vote on the fee's rate, what is the highest price you would accept to pay for a 35-liters bag?" We accepted responses between 0 and 5 CHF, at increments of 50 cents. Note that this scenario is very realistic as people regularly vote on local, regional, and national issues.

This survey instrument measures political acceptability of the tax. Note that this is different from willingness to pay. A rich individual, with high willingness to pay to get rid of her or his garbage without time-consuming sorting activities, may well indicate a politically acceptable price of zero in our survey. The survey item measures how politically acceptable PGB is.

Figure 4 shows the distribution of acceptable prices for 2012 and 2013. For both years and groups the distribution is not normal and clusters at 0 and 2 (the official price for a 35 liters bag). In the treated group, 59 percent of individuals indicated an acceptable price of zero, as opposed to 38 percent in the control group, before the implementation of PGB. There is a striking difference in the average acceptable price as well. Treated municipalities are willing to vote for a price of 0.89 cents, whereas control municipalities would vote for 1.49 CHF, or 67 percent higher than in the not-yet treated group.

In 2013, after PGB has been introduced in treated municipalities, the distributions of acceptable prices overlap. The proportion of people indicating an acceptable price of 0 is 35 percent in treated municipalities, and 31 percent in control municipalities. Interestingly, the modal answer in both groups of municipalities is 2 CHF, the actual price of a garbage bag. The average acceptable price in the treatment group is 1.55 CHF, and 1.57 CHF in the control group. Hence, people increase by 70% the stated maximum price per garbage bag that they would approve in a ballot. Introducing PGB has removed any differences in the politically acceptable level of the garbage tax.

7 Conclusion

We address the question of unit-pricing programs' effectiveness. We provide causal estimates of pricing garbage by the bag's effect on the amount of solid waste incinerated in the Canton of Vaud,

Switzerland. The identification strategy relies on the forced implementation on January 1, 2013, of pricing garbage by the bag in many municipalities of the Canton of Vaud, due to a ruling decision by the Federal Supreme Court of Switzerland, creating a difference-in-differences situation.

Both survey-based household panel data and official data are used. We find that estimates are consistent across datasets. Pricing garbage by the bag causes a reduction in the amount of incinerated garbage per capita by about 40%, implying a price elasticity of demand of about -0.3. Lower incinerated garbage is accompanied by a higher frequency of recycling of e.g. organic waste and aluminum. Our estimates are robust to the presence of simultaneous introduction of other measures that make garbage collection easier. Applying a regression-discontinuity design we rule out the potential risk of substantial leakage effects on surrounding municipalities. PGB's net benefit is on the order of 36 percent of total waste management cost.

We also analyze people's beliefs concerning PGB's effectiveness and fairness. Our key result is a sizable gap between *ex ante* beliefs and *ex post* beliefs. People initially believe the tax is unfair and does not work, but implementing it improves the program's perception of effectiveness and fairness. The environmental tax seems to be better understood once the policy it is in place.

Biased beliefs can be an obstacle to implementing Pigou taxes. People are pessimistic about a Pigou tax before they experience it, and become more optimistic once a Pigou tax has been implemented. If people hold pessimistic beliefs at the time of democratic decision making, many Pigou taxes will not be implemented. Our setting shows a way out of this stalemate. Outside force, e.g. the Supreme Court mandate, can force people to experience the Pigou tax, thereby updating beliefs, as in the context that we have analyzed. Our context does not allow municipalities to revert the changes forced unto them which is a key problem.

In an ideal world, people could decide on keeping the new policy or returning to the status quo after testing it. Policies forced onto people that remain detested could be abandoned after the trial period. Policies that people embrace after living with them would remain. A mechanisms dealing with incorrect beliefs would force people to implement a new Pigou tax temporarily but allow them to keep it or abandon it after a trial period.

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Figures

FIGURE 1 – Parallel trends: treatment and control groups

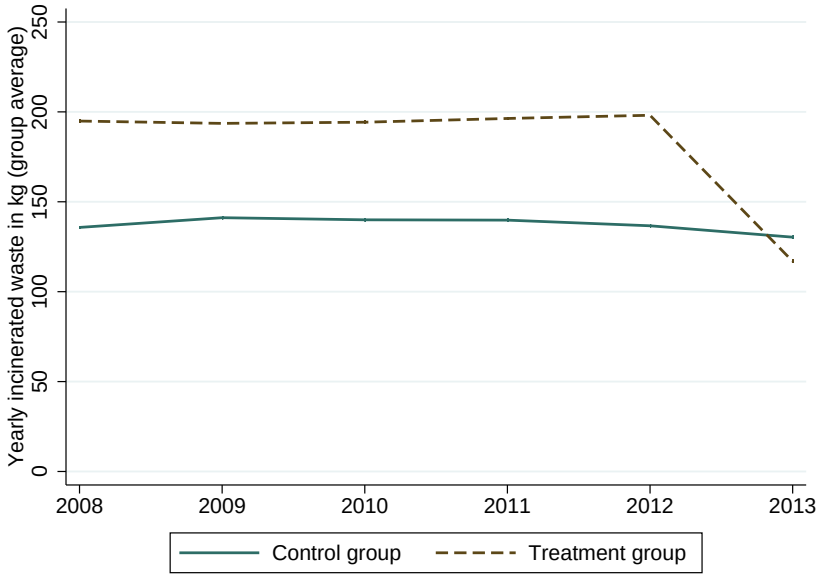


FIGURE 2 – Treatment effect on solid waste per capita in liters per week

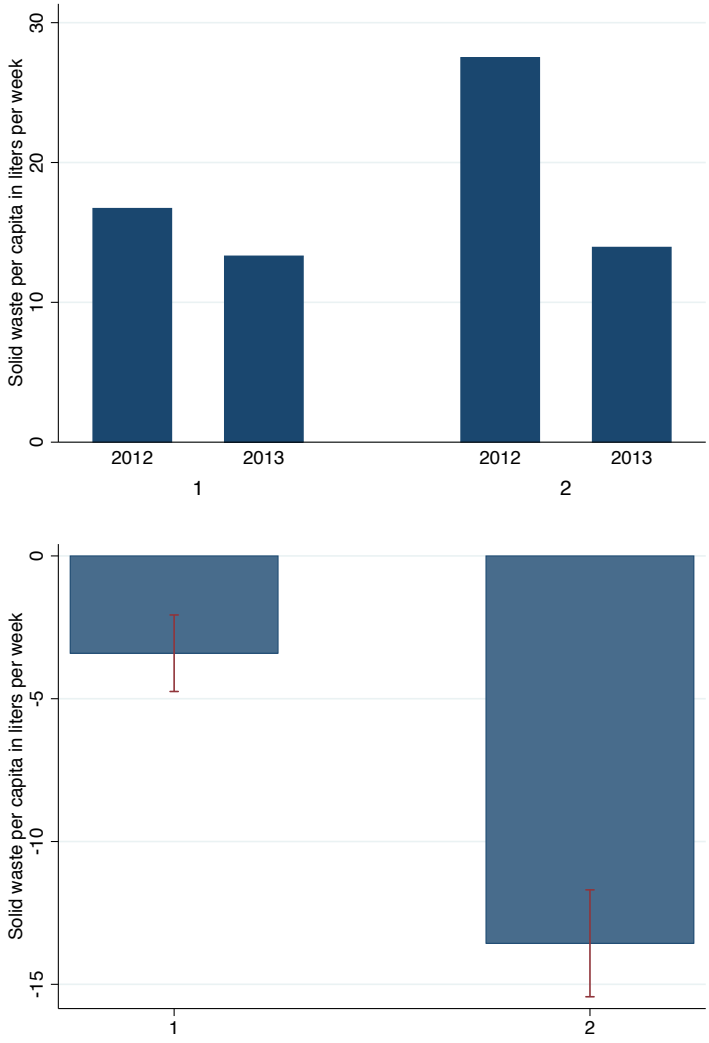


FIGURE 3 – Effect on surrounding municipalities: regression discontinuity design

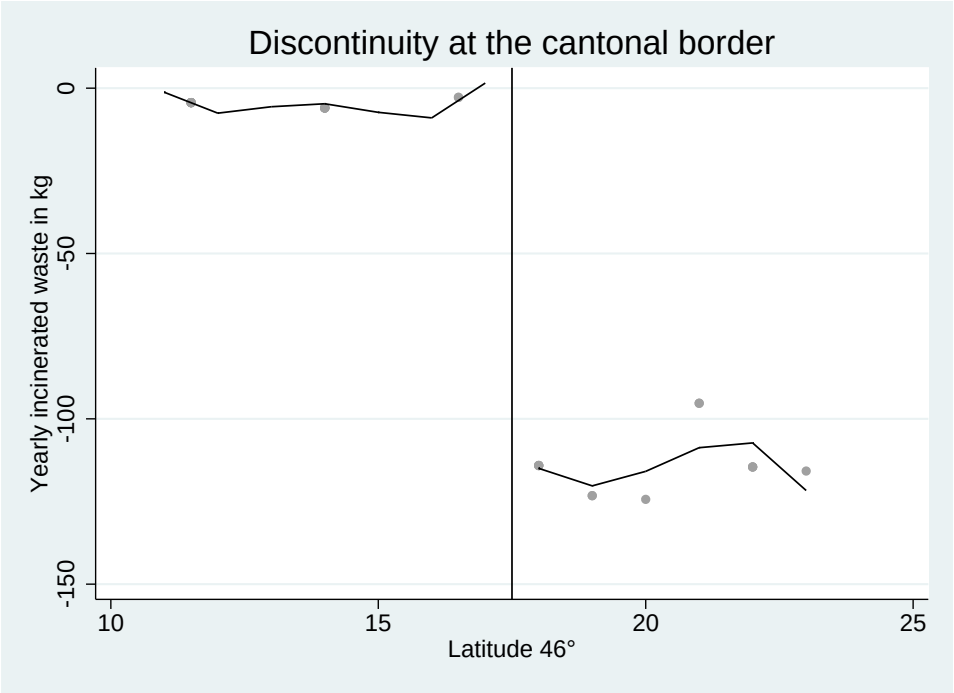
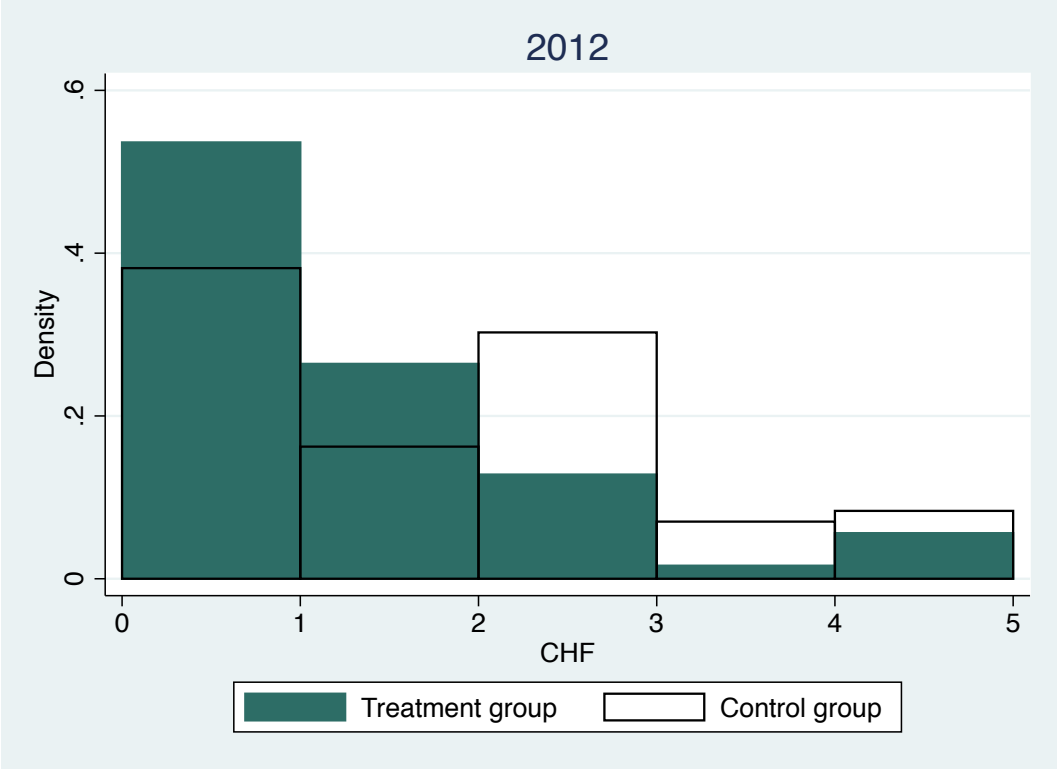
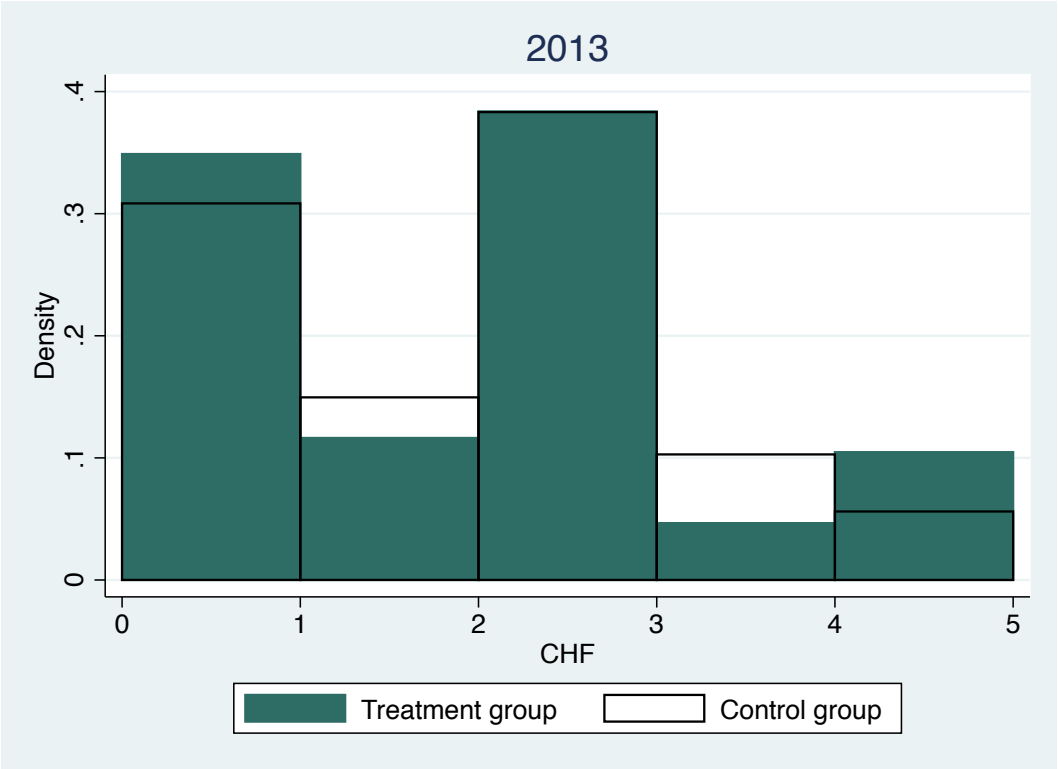


FIGURE 4 – Voting Intentions, Histogram





Tables

TABLE 1 – Solid waste, recycling and voluminous wrapping: mean comparison between 2012 and 2013

	2012		2013	
Variable	Treatment	Control	Treatment	Control
Per capita	27.385	16.187	13.875	13.153
Per household	65.906	39.728	33.647	35.061
	N=85	N=103	N=85	N=98
PET	0.919	0.981	0.953	0.944
Carton	0.849	0.944	0.965	0.907
Paper	0.895	0.972	0.953	0.935
Textiles	0.872	0.897	0.907	0.841
Cans	0.733	0.925	0.756	0.738
Organic waste	0.698	0.85	0.884	0.841
Batteries	0.942	0.935	0.988	0.897
Aluminum	0.733	0.907	0.93	0.869
	N=86	N=107	N=86	N=107
Attention to wrapping	0.471	0.551	0.571	0.608
	N=85	N=107	N=84	N=102

TABLE 2 – Treatment effect on solid waste per capita in liters per week

	(1)		(2)	
PGB	-10.51***	(1.921)	-9.668***	(2.009)
Year 2013	-2.847**	(1.184)	-2.845**	(1.360)
Gender (M)			-2.192	(2.079)
Age			-0.0904	(0.0783)
EU			4.012*	(2.319)
Rest of the world			-1.745	(4.424)
Adults in households			-5.644***	(1.453)
Children in households			-1.465	(1.023)
Apprenticeship			-2.626	(2.515)
High school			-2.275	(3.738)
University			-8.055***	(2.496)
Jobless			-1.462	(12.73)
Homemaker			-11.32	(12.36)
Employee			-8.208	(11.23)
Self-employed			-6.783	(10.45)
Manager			-8.632	(12.55)
Retiree			-10.36	(11.60)
Green			-0.159	(3.440)
Renter			-2.110	(1.822)
Distance			0.268*	(0.142)
Income category 1			-18.40***	(3.487)
Income category 2			-2.309	(3.972)
Income category 3			-5.919*	(3.282)
Income category 4			-5.629	(3.868)
Income category 5			0.733	(3.956)
Income is missing			-7.642**	(3.242)
Constant	21.23***	(0.467)	56.12***	(12.70)
Within-R^2	0.117		0.295	
N	371		359	

Note: Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 3 – Treatment effect on recycling and wrapping

	(1) Aluminum	(2) Battery	(3) Carton	(4) Textiles	(5) Glass	(6) Organic waste	(7) Paper	(8) PET	(9) Wrapping
					OLS				
PGB	0.235***	0.0839	0.154**	0.0910	0.0885*	0.195***	0.0955*	0.0723	0.0497
	(0.0718)	(0.0519)	(0.0652)	(0.0683)	(0.0443)	(0.0695)	(0.0528)	(0.0475)	(0.0914)
Year 2013	-0.0374	-0.0374	-0.0374	-0.0561	-0.0187	-0.00935	-0.0374	-0.0374	0.0558
	(0.0401)	(0.0403)	(0.0391)	(0.0487)	(0.0295)	(0.0509)	(0.0321)	(0.0291)	(0.0612)
Within-R^2	0.047	0.009	0.0258	0.006	0.017	0.032	0.012	0.008	0.008
N	386	386	386	386	386	386	386	386	378
					OLS (with control variables)				
PGB	0.195**	0.0288	0.107	0.0335	0.0206	0.144**	0.0361	0.00896	0.0561
	(0.0745)	(0.0511)	(0.0656)	(0.0766)	(0.0355)	(0.0645)	(0.0531)	(0.0412)	(0.0987)
Year 2013	-0.00107	0.0192	0.00331	-0.00975	0.0281	0.0369	0.00225	0.00447	0.0577
	(0.0423)	(0.0373)	(0.0360)	(0.0542)	(0.0180)	(0.0470)	(0.0228)	(0.0183)	(0.0682)
Within-R^2	0.101	0.059	0.088	0.069	0.133	0.166	0.112	0.093	0.222
N	368	368	368	368	368	368	368	368	365
					Logit				
PGB	0.264***	0.209***	0.207***	0.116	0.200***	0.232***	0.191**	0.177**	0.0692
	(0.0576)	(0.0493)	(0.0468)	(0.0710)	(0.0653)	(0.0724)	(0.0762)	(0.0879)	(0.0757)
Year 2013	-0.0683	-0.0857	-0.0773	-0.0812	-0.0606	-0.0174	-0.126	-0.146	0.0582
	(0.0736)	(0.0940)	(0.0810)	(0.0689)	(0.0962)	(0.0944)	(0.107)	(0.113)	(0.110)
Pseudo-R^2	0.119	0.079	0.096	0.056	0.096	0.097	0.064	0.072	0.084
N	234	120	184	250	112	246	144	136	343

Note: Marginal effects are reported for Logit (all discrete changes). Brute force fixed effects.

Individuals bypassed if Y_{ict} always =0 or always =1 (fixed effects cannot be computed).

Clustered standard errors in parentheses (cluster per municipality). * $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$.

TABLE 4 – Non-tax waste management policies undertaken between 2012 and 2013: descriptive statistics

Variable	Treatment group	Control group
	Mean	
Additional skip available for the recycling of:		
Paper	0.117	0.043
Carton	0.064	0.06
PET	0.17	0.043
Textiles	0.117	0.06
Glass	0.17	0.043
Cans	0.117	0.043
Batteries	0.117	0.043
Aluminum	0.064	0.043
Plastic	0.085	0
Wood	0	0.017
Organic waste	0.117	0.138
Additional skips: number of materials covered	1.138	0.534
New collection center	0.064	0.043
Collection centers: better opening hours	0.223	0.155
New curbside program	0.074	0.034
Awareness-raising campaign: unaddressed mailshot	0.5	0.345
Awareness-raising campaign: information session	0.117	0
Awareness-raising campaign: street stand	0.021	0
Awareness-raising campaign: specific website	0	0.017
N	94	116

TABLE 5 – Treatment effect on solid waste per capita in liters per week (non-tax policies)

	(1)	(2)	(3)
PGB	-12.20***	-11.08***	-10.89***
	(3.129)	(3.762)	(3.763)
Year 2013	-1.777	-2.692	-2.894
	(1.904)	(3.299)	(3.241)
Additional skips: number of materials covered		-1.340**	-1.305**
		(0.606)	(0.615)
Collection centers: better opening hours		6.104	5.970
		(4.170)	(4.258)
New curbside program		-9.383	-9.451
		(6.330)	(6.490)
New collection center		6.918**	7.213**
		(2.690)	(2.720)
Awareness-raising campaign: unaddressed mailshot		0.647	0.699
		(4.462)	(4.456)
Constant	21.71***	21.68***	30.67***
	(0.765)	(0.748)	(4.912)
Socio-economic variables	No	No	Yes
Within-R^2	0.105	0.115	0.153
N	205	205	205

Note: Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 6 – Treatment effect on solid waste per capita in kilos per year (official data, extended samples)

	Survey	Volume	+Weight	Heterogeneous
	(1)	(2)	(3)	(4)
PGB	-86.14***	-80.03***		-109.37**
	(12.26)	(4.380)		(31.56)
PGB				0.8556
· Green votes				(1.85)
Year 2013	-11.15**	-8.487***	-7.969***	-10.20***
	(4.346)	(3.178)	(2.748)	(3.233)
Unit pricing			-79.78***	
			(4.064)	
Constant	173.6***	186.6***	181.3***	172.2***
	(2.380)	(1.179)	(1.117)	(1.834)
Within-R^2	0.715	0.828	0.822	0.834
N	116	434	470	114

Note: Robust standard errors in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 7 – Effect on surrounding municipalities: sharp regression discontinuity estimates using local polynomial regression

	(1)
Regression discontinuity estimate	-106.5***
	(37.56)
Total observations	11
Observations (left)	5
Observations (right)	6
Order local polynomial (p)	1
Order bias (q)	2
Available observations	32

Note: Standard errors in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 8 – Effect on surrounding municipalities: linear regression on both sides of the cutoff

	Left of the cut-off	Right of the cut-off
	(1)	(2)
Latitude	4.139	-9.124
	(2.217)	(30.48)
Constant	-70.55	50.12
	(36.61)	(573.4)
R^2	0.402	0.013
N	5	6

Note: Robust standard errors in parentheses.

* $p < 0.1$, **$p < 0.05$, *** $p < 0.01$

TABLE 9 – Policy perception: effect of PGB's implementation in the treatment group (OLS)

	(1)	(2)	(3)	(4)
	Eff. env.	Eff. env.	Use rev.	Use rev.
PGB	0.165*	0.203**	0.421***	0.458***
	(0.0899)	(0.0968)	(0.0780)	(0.0831)
Year 2013	-0.0251	-0.0268	0.0188	0.0155
	(0.0602)	(0.0633)	(0.0519)	(0.0566)
Constant	0.667***	1.225***	0.502***	0.495*
	(0.0224)	(0.378)	(0.0195)	(0.272)
Socio-economic variables	No	Yes	No	Yes
Within-R^2	0.013	0.119	0.116	0.214
N	385	368	383	365

	(5)	(6)	(7)	(8)
	Unfair taxes	Unfair taxes	Unfair sort	Unfair sort
PGB	-0.160*	-0.208**	-0.253***	-0.312***
	(0.0801)	(0.0838)	(0.0910)	(0.0977)
Year 2013	-0.0376	-0.00346	0.0439	0.0925
	(0.0486)	(0.0530)	(0.0583)	(0.0658)
Constant	0.410***	0.617	0.437***	0.397
	(0.0196)	(0.473)	(0.0225)	(0.423)
Socio-economic variables	No	Yes	No	Yes
Within-R^2	0.028	0.181	0.026	0.142
N	385	368	385	368

	(9)	(10)	(11)	(12)
	Unfair ineq.	Unfair ineq.	Leg. cush.	Leg. cush.
PGB	-0.0186	-0.0375	-0.0671	-0.00935
	(0.0749)	(0.0780)	(0.0896)	(0.0937)
Year 2013	-0.144***	-0.118***	0.273***	0.248***
	(0.0413)	(0.0440)	(0.0557)	(0.0597)
Constant	0.219***	0.239	0.316***	0.479
	(0.0181)	(0.337)	(0.0221)	(0.370)
Socio-economic variables	No	Yes	No	Yes
Within-R^2	0.057	0.114	0.070	0.181
N	385	368	383	365

Note: Clustered standard errors in parentheses (cluster per municipality). Cluster standard errors in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix

A Appendix tables

TABLE A.1 – Sample's socioeconomic characteristics: mean comparisons and tests

	Interviewed only in 2012		Panel	
	Treatment group	Control group	Treatment group	Control group
Gender (M)	0.41	0.331	0.43	0.327
Age	54.615	58.392	56.395	56.093
Switzerland	0.821	0.842	0.791	0.879
European Union	0.154	0.133	0.186	0.075*
Rest of the world	0.026	0.025	0.023	0.047
Adults in households	2.103	2.042	1.942*	2.131
Children in households	0.974	0.587	0.674*	0.71
Households	38	121	86	107
Total households	159		193	
Compulsory schooling	0.135	0.153	0.070	0.190
Apprenticeship	0.405	0.369	0.477	0.343
High school	0.135	0.234	0.104	0.143**
University	0.324	0.243	0.349	0.324*
Jobless	0.026	0.008	0.023	0
Student	0	0	0	0
Homemaker	0.079	0.084	0.058	0.066
Employee	0.447	0.303	0.384	0.34
Self-employed	0.184	0.151	0.151	0.094*
International civil servant	0	0	0	0
Manager	0	0.042	0.047*	0.075
Retired	0.237	0.403	0.337	0.387
Income category 1 (<3'000 CHF)	0.026	0.041	0.058	0.075
Income category 2 (3'001-5'000 CHF)	0.051	0.165	0.093	0.168
Income category 3 (5'001-7'000 CHF)	0.103	0.124	0.198*	0.121
Income category 4 (7'001-9'000 CHF)	0.077	0.107	0.163*	0.037**
Income cateory 5 (9'001-15'000 CHF)	0.051	0.041	0.105	0.112*
Income category 6 (>15'001 CHF)	0.051	0.033	0.081	0.065
Missing value for income	0.641	0.488	0.302***	0.421
Distance from collecting center (in minutes)	7.836	5.784	6.368	4.918*
Green	0.135	0	0.093	0
Households	37	116	85	103
Total households	153		188	

Note: *, ** and *** imply statistically-significant differences in the mean for the same group between samples at 10%, 5% and 1%, respectively. No missing values affect the first block of variables (from gender to children in the household). Income is measured as household monthly gross income in Swiss francs (CHF). We also obtain a measure of distance from the closest collecting center (in kilometers and in minutes with the appropriate transport mode) from respondents, which is however not available in the official statistics. To avoid excessive missing values we impute distance in time from distance in space whenever needed and use the former as variable. We qualify as "green" the members of environmental organizations. A measure of general trust as used by the World Values Survey and other large surveys (cf. e.g. Glaeser et al. 2000) is included only in the survey of 2013 and does not allow for comparison between samples. The same applies to the proportion of renters (versus homeowners). Trust is 0.5 in the treatment group and 0.42 in the control group. Renters are 0.34 in the treatment group and 0.33 in the control group.

TABLE A.2 – Canton of Vaud's socioeconomic characteristics

	Cantonal mean
Gender (M)	0.489
Age <20	0.222
Age 20-39	0.276
Age 40-64	0.340
Age >65	0.162
Switzerland	0.682
European Union (EU)	0.230
Rest of the world	0.088
Adults	0.776
Children	0.224
Single-adult households	0.386
Households without children	0.247
Households with children	0.277
Single-member households	0.063
Household size	2.2
Compulsory schooling	0.268
Apprenticeship	0.300
High school	0.091
University	0.321
Jobless	0.049
Student	0.080
Homemaker	0.127
Employee	0.480
Manager	0.065
Retired	0.094
Income <35'000 CHF	0.192
Income 35'001-60'000 CHF	0.220
Income 60'001-80'000 CHF	0.160
Income 80'001-100'000 CHF	0.114
Income 100'001-175'000 CHF	0.207
Income >175'001 CHF	0.107
Renters	0.694

Source: Swiss Federal Statistical Office and Statistique Vaud.

Note: Cantonal statistics refer to years 2012 or 2013 whenever data are available, to year 2011 otherwise. Cantonal data define as children individuals from age 0 to 19. Educational achievements are given only for population over 30 years. The level of education of 2% of the Canton is not know. The share of self-employed workers is not given. Income is measured as yearly gross income in Swiss francs (CHF). The proportion of renters is obtained from the negative of the share of housing assets with owners living in. No measure for trust is available at the Cantonal level. The World Values Survey wave of 2007 reports a level of trust of 0.539 for Switzerland. More recent data are available from the European Social Survey, which however uses a 10 points scale instead of a binary variable as in our survey.

TABLE A.3 – Treatment effect on recycling and wrapping (control variables)

	(1)		(2)		(3)	
	Aluminum		Battery		Carton	
PGB	0.195**	(0.0745)	0.0288	(0.0511)	0.107	(0.0656)
Year 2013	-0.00107	(0.0423)	0.0192	(0.0373)	0.00331	(0.0360)
Gender (M)	-0.0174	(0.0545)	0.0110	(0.0330)	0.0176	(0.0298)
Age	0.00130	(0.00184)	0.00143	(0.00145)	0.0000438	(0.00130)
EU	-0.0716	(0.0541)	-0.0823**	(0.0371)	-0.00425	(0.0376)
Rest of the world	0.109	(0.0892)	-0.0256	(0.0877)	0.0846	(0.0591)
Adults in households	0.0186	(0.0240)	-0.0267	(0.0268)	-0.0140	(0.0247)
Children in households	-0.0293	(0.0261)	-0.00880	(0.0146)	-0.0279	(0.0186)
Apprenticeship	-0.0120	(0.0644)	0.00162	(0.0546)	-0.00998	(0.0492)
High school	-0.0479	(0.0685)	-0.00507	(0.0560)	-0.00834	(0.0436)
University	0.0853	(0.0621)	0.0345	(0.0543)	-0.00229	(0.0510)
Jobless	0.330	(0.222)	-0.232**	(0.0928)	-0.102	(0.113)
Homemaker	0.278	(0.217)	-0.128	(0.0905)	-0.0445	(0.102)
Employee	0.235	(0.193)	-0.203***	(0.0712)	-0.124*	(0.0728)
Self-employed	0.251	(0.188)	-0.225***	(0.0835)	-0.182**	(0.0802)
Manager	0.239	(0.228)	-0.238**	(0.0944)	-0.125	(0.0944)
Retiree	0.222	(0.206)	-0.240**	(0.0954)	-0.160*	(0.0874)
Green	0.0431	(0.0646)	-0.00454	(0.0421)	0.0518	(0.0509)
Distance	-0.00205	(0.00476)	0.0000173	(0.00316)	-0.00520*	(0.00306)
Renter	0.0245	(0.0444)	0.00867	(0.0296)	-0.0228	(0.0371)
Income category 1	0.110	(0.119)	-0.00924	(0.0730)	0.108	(0.103)
Income category 2	0.109	(0.0942)	-0.00115	(0.0619)	0.119*	(0.0620)
Income category 3	0.0884	(0.0913)	0.0653	(0.0665)	0.0629	(0.0847)
Income category 4	0.0101	(0.0800)	0.0228	(0.0493)	0.0181	(0.0698)
Income category 5	-0.0275	(0.102)	-0.0222	(0.0561)	-0.0195	(0.0615)
Income is missing	0.0315	(0.0723)	-0.0124	(0.0557)	0.0945*	(0.0532)
Constant	0.460**	(0.222)	1.117***	(0.137)	1.055***	(0.128)
Within-R^2	0.101		0.059		0.088	
N	368		368		368	

Note: Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	(4) Textiles		(5) Glass		(6) Organic waste	
PGB	0.0335	(0.0766)	0.0206	(0.0355)	0.144**	(0.0645)
Year 2013	-0.00975	(0.0542)	0.0281	(0.0180)	0.0369	(0.0470)
Gender (M)	0.0232	(0.0552)	-0.00934	(0.0192)	0.0818*	(0.0487)
Age	0.00223	(0.00208)	0.000986	(0.000857)	0.00507**	(0.00218)
EU	-0.0850	(0.0611)	-0.0218	(0.0265)	-0.0414	(0.0664)
Rest of the world	0.0643	(0.120)	-0.156**	(0.0726)	0.00972	(0.171)
Adults in households	-0.0290	(0.0367)	-0.0195	(0.0218)	0.0160	(0.0353)
Children in households	-0.0126	(0.0271)	0.00483	(0.0106)	-0.00117	(0.0274)
Apprenticeship	-0.00251	(0.0615)	0.0212	(0.0353)	-0.0853	(0.0525)
High school	-0.0121	(0.0737)	0.00932	(0.0298)	-0.137*	(0.0784)
University	0.0573	(0.0584)	0.0303	(0.0330)	0.0162	(0.0598)
Jobless	-0.320***	(0.115)	0.0649	(0.111)	-0.0926	(0.282)
Homemaker	-0.130	(0.123)	0.158	(0.117)	-0.0111	(0.316)
Employee	-0.283***	(0.0967)	0.0712	(0.107)	0.0892	(0.261)
Self-employed	-0.322***	(0.0986)	0.0533	(0.109)	-0.00952	(0.265)
Manager	-0.352**	(0.160)	0.0574	(0.109)	0.106	(0.271)
Retiree	-0.298**	(0.113)	0.0478	(0.107)	0.0118	(0.262)
Green	-0.0106	(0.0701)	0.0149	(0.0228)	0.0143	(0.0674)
Distance	-0.00677*	(0.00352)	-0.00438**	(0.00212)	-0.0208***	(0.00485)
Renter	-0.0162	(0.0486)	0.00813	(0.0223)	0.0446	(0.0456)
Income category 1	0.0639	(0.123)	0.0256	(0.0489)	0.135	(0.128)
Income category 2	0.0795	(0.103)	-0.0415	(0.0616)	0.0748	(0.0969)
Income category 3	0.147*	(0.0869)	0.00454	(0.0687)	-0.0716	(0.123)
Income category 4	0.0778	(0.0946)	0.0534	(0.0532)	0.00856	(0.106)
Income category 5	0.0103	(0.0949)	0.0128	(0.0511)	-0.159	(0.125)
Income is missing	0.0795	(0.0796)	0.0362	(0.0516)	-0.00912	(0.102)
Constant	1.070***	(0.206)	0.871***	(0.152)	0.567	(0.363)
Within-R^2	0.069		0.133		0.166	
N	368		368		368	

Note: Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	(7) Paper		(8) PET		(9) Wrapping	
PGB	0.0361	(0.0531)	0.00896	(0.0412)	0.0561	(0.0987)
Year 2013	0.00225	(0.0228)	0.00447	(0.0183)	0.0577	(0.0682)
Gender (M)	-0.0190	(0.0223)	0.0128	(0.0188)	-0.129*	(0.0736)
Age	0.00377***	(0.00126)	0.00182*	(0.00100)	0.00367	(0.00279)
EU	-0.00865	(0.0328)	-0.0277	(0.0337)	-0.179*	(0.105)
Rest of the world	0.0440	(0.0665)	-0.0234	(0.0853)	0.160	(0.146)
Adults in households	0.0235	(0.0206)	-0.0166	(0.0169)	-0.0868*	(0.0480)
Children in households	0.000532	(0.0120)	0.0217**	(0.0108)	-0.0382	(0.0377)
Apprenticeship	-0.0179	(0.0399)	-0.00308	(0.0327)	-0.0674	(0.103)
High school	0.0318	(0.0420)	0.0453	(0.0291)	-0.0892	(0.116)
University	0.0393	(0.0394)	0.00968	(0.0327)	0.0428	(0.0979)
Jobless	-0.0362	(0.0465)	-0.0661	(0.0785)	0.0870	(0.248)
Homemaker	-0.0443	(0.0523)	-0.0621	(0.0632)	0.181	(0.249)
Employee	-0.120**	(0.0481)	-0.108	(0.0651)	0.166	(0.149)
Self-employed	-0.126**	(0.0578)	-0.123*	(0.0691)	0.123	(0.152)
Manager	-0.114*	(0.0602)	-0.0676	(0.0746)	0.410*	(0.225)
Retiree	-0.143**	(0.0689)	-0.0987	(0.0727)	0.213	(0.160)
Green	0.0599*	(0.0302)	0.0381	(0.0274)	0.0697	(0.0988)
Distance	-0.00642**	(0.00250)	-0.00421*	(0.00250)	-0.00541	(0.00773)
Renter	0.00529	(0.0297)	0.0303	(0.0255)	-0.0363	(0.0753)
Income category 1	0.0850	(0.0610)	0.0768	(0.0829)	0.487***	(0.182)
Income category 2	0.0550	(0.0679)	0.0493	(0.0781)	0.205	(0.152)
Income category 3	0.0655	(0.0772)	0.165**	(0.0760)	0.201	(0.130)
Income category 4	0.0611	(0.0522)	0.108	(0.0688)	0.625***	(0.120)
Income category 5	-0.00134	(0.0627)	0.0657	(0.0690)	0.00950	(0.167)
Income is missing	0.0192	(0.0596)	0.111*	(0.0608)	0.330**	(0.126)
Constant	0.798***	(0.106)	0.886***	(0.130)	0.191	(0.299)
Within-R^2	0.112		0.093		0.222	
N	368		368		365	

Note: Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.4 – Treatment effect on solid waste per capita in kilos per year (official data, survey sample, non-tax policies)

	(1)	(2)	(3)
PGB	-86.14***	-84.80***	-82.73***
	(12.26)	(16.25)	(19.86)
Year 2013	-11.15**	-7.579**	-6.619
	(4.346)	(3.407)	(7.496)
Additional skips: number of materials covered			-0.110
			(2.669)
Collection centers: better opening hours			-16.00
			(13.81)
New curbside program			17.04
			(14.27)
New collection center			12.49*
			(6.282)
Awareness-raising campaign: unaddressed mailshot			1.356
			(10.01)
Constant	173.6***	178.7***	178.7***
	(2.380)	(3.012)	(3.062)
Within-R^2	0.715	0.724	0.737
N	116	68	68

Note: Robust standard errors in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.5 – Policy perceptions: mean comparison between 2012 and 2013

		2012		2013	
		Treatment group	Control group	Treatment group	Control group
Variable	Short	Mean	Mean	Mean	Mean
Perceived effectiveness on own behavior	Eff. own	0.419	0.411	0.547	0.383
		N=86	N=107	N=86	N=107
Perceived effectiveness	Effectiveness	0.784	0.839	0.928	0.878
		N=74	N=93	N=69	N=90
Perceived effect on the environment	Eff. env.	0.581	0.736	0.721	0.71
Use of revenues for other purposes	Use rev.	0.262	0.689	0.709	0.71
Unfair: inequitable	Unfair ineq.	0.233	0.208	0.07	0.065
Unfair: paying enough taxes	Unfair taxes	0.547	0.302	0.349	0.262
Unfair: paying even if sorting	Unfair sort	0.558	0.34	0.349	0.383
		N=86	N=106	N=86	N=107
Legitimacy provided social cushioning	Leg. cush.	0.353	0.286	0.558	0.561
		N=85	N=105	N=86	N=107

TABLE A.6 – Policy perception: effect of the PGB's implementation in the treatment group (Logit)

	(1) Eff. env.	(2) Eff. env.	(3) Use rev.	(4) Use rev.
PGB	0.174*	0.220**	0.439***	0.499***
	(0.0909)	(0.0879)	(0.0696)	(0.0708)
Year 2013	-0.0340	-0.0358	0.0277	0.0324
	(0.0813)	(0.0862)	(0.0767)	(0.0922)
Socio-economic variables	No	Yes	No	Yes
Pseudo-R^2	0.089	0.193	0.186	0.293
N	337	324	333	314

	(5) Unfair taxes	(6) Unfair taxes	(7) Unfair sort	(8) Unfair sort
PGB	-0.188*	-0.286***	-0.271***	-0.358***
	(0.102)	(0.0957)	(0.0919)	(0.0917)
Year 2013	-0.0590	-0.0031	0.0576	0.132
	(0.0761)	(0.0907)	(0.0763)	(0.0904)
Socio-economic variables	No	Yes	No	Yes
Pseudo-R^2	0.163	0.312	0.104	0.198
N	326	311	355	342

	(9) Inequitable	(10) Inequitable	(11) Leg. cush.	(12) Leg. cush.
PGB	-0.0190	-0.0411	-0.0961	-0.0269
	(0.117)	(0.0941)	(0.102)	(0.121)
Year 2013	-0.229***	-0.166***	0.317***	0.321***
	(0.0675)	(0.0678)	(0.0631)	(0.0734)
Socio-economic variables	No	Yes	No	Yes
Pseudo-R^2	0.167	0.259	0.127	0.218
N	249	236	374	356

Note: Estimates report marginal effects (all discrete changes). Brute force fixed effects.

Individuals bypassed if Y_{ict} always =0 or always =1 (fixed effects cannot be computed).

Clustered standard errors in parentheses (cluster per municipality).

* $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$.

B Questionnaires[21]

Survey of 2012

1. Does your household sort the following materials?
   (multiple answers)

   - PET bottles
   - Carton
   - Paper
   - Textiles
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum

2. Do you pay attention to wrapping while shopping?

   - Yes
   - No

3. a. How many bags does your household fill with garbage every week?

   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10

3. b. Bags volume

   - 17 liters
   - 35 liters

4. Does the pay-per-bag fee incite you to pay more attention to volominuous wrapping while shopping?
   (if applicable)

   - Yes
   - No

[21]The original and full questionnaires were in French. They are available by the authors upon request.

5. If you would be asked to vote on the fee's rate, what is the highest price you would accept to pay for a 35-liters bag?
   (please select the value that is closer to your preferences, in CHF)

   - 0
   - 0.50
   - 1
   - 1.50
   - 2
   - 2.50
   - 3
   - 3.50
   - 4
   - 4.50
   - 5

6. In your opinion, the pay-per-bag fee:
   (multiple answers)

   - Allows for the application of the polluter-pays principle
   - Contributes to the quality of the environment
   - Lowers the waste management costs
   - Favors high-income households and is thus inequitable
   - Makes you paying even if you already sort your garbage
   - Is unfair because you already pay enough taxes
   - Is useless, since it does not change people's behavior

7. The pay-per-bag fee could imply a higher expenditure for low-income households:

   - In spite of this, you think that the fee is legitimate
   - You think that the fee is legitimate provided that low-income households are compensated
   - This fact does not influence your opinion on the pay-per-bag fee

8. Do you consider the pay-per-bag fee as effective, in the sense that it incites the inhabitants of your municipality to recycle more of their garbage and pay more attention to voluminous wrapping?

   - Yes
   - No
   - You do not know

9. Would you accept a pay-per-bag fee whose revenues would be used to fund some public expenditures other than waste management, such as education, safety?

    - Yes, what is important is that what is paid depends on the amount of garbage incinerated and that the polluter-pays principle is applied
    - Yes, so that your municipality can afford to finance other projects thanks to the fee's revenues
    - No, I think that the pay-per-bag fee's must be used to finance the management of waste only
    - No, I am against the fee anyway

Socio-economic characteristics

10. Gender

    - Female
    - Male

11. Municipality
12. Age
13. Of how many people is your household composed? Adults?
14. Children?
15. Nationality

    - Switzerland (specify canton of birth)
    - European Union (specify country)
    - Other (specify country)

16. What is the highest level of education that you attained?

    - Compulsory schooling
    - Apprenticeship
    - Post-compulsory schooling
    - Tertiary education

17. What is your current professional profile?

    - Homemaker
    - Student
    - Employee
    - Manager
    - Self-employed
    - International civil servant
    - Jobless
    - Retired

18. Are you a member of an environmental organization?
    (participating financially is a sufficient condition)

    - Yes
    - No

19. a. Could you estimate the distance between your residence and the closest collection center?
    (in minutes, with the usual transportation mode)

18. b. Could you estimate the distance between your residence and the closest collection center?
    (in kilometers, approximating)

19. What is the monthly gross income of your household?

    - $<$ 3'000 CHF
    - 3'001-5'000 CHF
    - 5'001-7'000 CHF
    - 7'001-9'000 CHF
    - 9'001-15'000 CHF
    - $>$ 15'001 CHF
    - No answer

Survey of 2013

1. Does your household sort the following materials?
   (multiple answers)

   - PET bottles
   - Carton
   - Paper
   - Textiles
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum

2. Do you pay attention to wrapping while shopping?

   - Yes
   - No

3. a. How many bags does your household fill with garbage every week?

   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10

3. b. Bags volume

   - 17 liters
   - 35 liters

4. If you would be asked to vote on the fee's rate, what is the highest price you would accept to pay for a 35-liters bag?
   (please select the value that is closer to your preferences, in CHF)

   - 0
   - 0.50
   - 1
   - 1.50
   - 2
   - 2.50
   - 3
   - 3.50
   - 4
   - 4.50
   - 5

5. In your opinion, the pay-per-bag fee:
   (multiple answers)
   - Allows for the application of the polluter-pays principle
   - Contributes to the quality of the environment
   - Lowers the waste management costs
   - Favors high-income households and is thus inequitable
   - Makes you paying even if you already sort your garbage
   - Is unfair because you already pay enough taxes
   - Is useless, since it does not change people's behavior
6. The pay-per-bag fee could imply a higher expenditure for low-income households:
   - In spite of this, you think that the fee is legitimate
   - You think that the fee is legitimate provided that low-income households are compensated
   - This fact does not influence your opinion on the pay-per-bag fee
7. Do you consider the pay-per-bag fee as effective, in the sense that it incites the inhabitants of your municipality to recycle more of their garbage and pay more attention to voluminous wrapping?
   - Yes
   - No
   - You do not know
8. Would you accept a pay-per-bag fee whose revenues would be used to fund some public expenditures other than waste management, such as education, safety?
   - Yes, what is important is that what is paid depends on the amount of garbage incinerated and that the polluter-pays principle is applied
   - Yes, so that your municipality can afford to finance other projects thanks to the fee's revenues
   - No, I think that the pay-per-bag fee's must be used to finance the management of waste only
   - No, I am against the fee anyway

Socio-economic characteristics

9. Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?
    - Most people can be trusted
    - You can never be too careful when dealing with others
10. Municipality
11. Are you:
    - Renter
    - Homeowner

Survey to the municipalities

1. Municipality
2. Between 2012 and 2013, how many (if any) new collection centers were introduced in your municipality?
3. Between 2012 and 2013, did your municipality introduce new skips for the following materials?

   - PET bottles
   - Carton
   - Paper
   - Textiles
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum
   - Plastics
   - Other (specify)

4. Between 2012 and 2013, were the opening hours of the collection centers in your municipality prolonged?

   - Yes
   - No

5. Between 2012 and 2013, did your municipality implement a system of curbside collection for the following materials?

   - PET bottles
   - Carton
   - Paper
   - Textiles
   - Glass
   - Cans
   - Organic waste
   - Batteries
   - Aluminum
   - Plastics
   - Other (specify)

6. Between 2012 and 2013, did your municipality launch any awareness-raising campaign with the aim of spurring recycling such as:

   - Information sessions
   - Street stands
   - Advertising
   - Other (specify)